FISHERY RESEARCH

KOOTENAI RIVER WHITE STURGEON SPAWNING AND RECRUITMENT EVALUATION

ANNUAL PROGRESS REPORT
April 1, 2001 to March 31, 2002

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ABSTRACT

Sampling for adult Kootenai River white sturgeon *Acipenser transmontanus* began in March and continued through April 2001. Seventy-one adult white sturgeon were captured with 3,587 hours of angling and setlining effort, while four additional adult sturgeon were captured while gillnetting for juveniles. Flows were low in 2001 because the snow pack in the basin was estimated at 65% of normal. Because the basin was in drought condition, no flows were provided for white sturgeon spawning and rearing in 2001. Flows in the Kootenai River at Bonners Ferry during April peaked at 384 m^3/s (13,530 cfs) on April 29. Flows subsided by early May to about 243 m^3/s (8,568 cfs) but rose to 393 m^3/s (13,042 cfs) by May 14 because of local runoff. Flows dropped to 272 m^3/s (9,589 cfs) by May 21 and then rose again to 383 m^3/s (13,515 cfs). At this time, flows dropped and stayed below 240 m^3/s through June. Water temperature ranged from 6-17°C (43-62°F) from May through June. We monitored the movements of 20 adult sturgeon from September 1, 2000 to August 31, 2001. These included fish in Kootenay Lake, British Columbia (BC), and the Kootenai River in Idaho and BC. Thirteen adult white sturgeon with transmitters were located in the spawning reach. Sampling with artificial substrate mats (hereafter mat) began May 1 and ended June 29, 2001. We sampled for 2,823 mat d (a mat d is one 24 h set) during white sturgeon spawning. A total of 139 white sturgeon eggs were collected from May 29 through June 23, 2001. A single mat on May 29 held 86 eggs comprising 62% of the total collection. Forty-three of the eggs were determined to be dead or damaged. Mats collected eggs within three of 14 different geographic river sections that we sampled. The Middle Shorty's Island reach (rkm 229.6-231.5) produced the most white sturgeon eggs (113) with 389 mat d of effort, the U.S. Highway 95 section (rkm 244.7 to 246.6) produced 22 eggs with 315 mat d of effort, and the Refuge section (rkm 234.8 to 237.5) produced four eggs with 939 mat d of effort. Ten spawning events were identified from May 25 through June 23, 2001. An experimental release of 135,000 white sturgeon larvae from the Kootenai Tribe of Idaho Hatchery began on June 20. Ninety-seven of the 135,000 hatchery larvae were caught soon after their release, indicating our gear is suitable for sampling sturgeon larvae in the Kootenai River providing larvae are available. However, no wild sturgeon larvae were caught during our ½ m and D-ring sampling efforts. We expended a total of 503 h of gill netting effort and captured 426 juvenile white sturgeon from July 17 through August 30, 2001. Seven of the total juveniles captured were wild. Recommendations for the 2002 spawning season include coordinating the flow test with sturgeon spawning behavior and targeting river temperatures of 8-10°C (46-50°F).

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OBJECTIVE

1. Determine environmental requirements for adequate spawning and recruitment of white sturgeon *Acipenser transmontanus*.

STUDY SITE

The Kootenai River originates in Kootenay National Park, British Columbia (BC). The river flows south into Montana and turns northwest at Jennings, the site of Libby Dam, at river kilometer (rkm) 352.4 (Figure 1). Kootenai Falls, 42 km (26 mi) below Libby Dam, is thought to be an impassable barrier to sturgeon. As the river flows through the northeast corner of Idaho, there is a gradient transition at Bonners Ferry. Upriver from Bonners Ferry the channel has an average gradient of 0.6 m/km (3.15 ft/mi) and the velocities are often higher than 0.8 m/s (2.6 ft/s). Downriver from Bonners Ferry the river slows, with velocities usually less than 0.4 m/s (1.3 ft/s). The average gradient is 0.02 m/km (0.1 ft/mi), the channel deepens, and the river meanders north through the Kootenai River Valley. The river returns to BC at rkm 170 and enters the South Arm of Kootenay Lake at rkm 120. The river leaves the lake though the West Arm of Kootenay Lake to its confluence with the Columbia River at Castlegar, BC. A natural barrier at Bonnington Falls (now a series of four dams) has isolated the Kootenai River white sturgeon from other populations in the Columbia River basin for approximately 10,000 years (Northcote 1973). The basin drains an area of 49,987 km^2 (19,300 mi^2) (Bonde and Bush 1975). Regulation of the Kootenai River with Libby Dam changed the natural hydrograph of the river. Post-Libby Dam flows during spring were reduced by about a third, and flows during winter are now three to four times higher (Figure 2). However, since 1991 mitigative flows have further changed the Kootenai River spring hydrograph to accommodate white sturgeon spawning (Figure 2).

METHODS

Discharge, Water Temperature, and Secchi Measurements

Kootenai River discharge and water temperature data at Bonners Ferry and discharge from Libby Dam were obtained from the U.S. Army Corps of Engineers (USACE). Because flows were at about 65% of normal, the U.S. Fish and Wildlife Service (USFWS) and USACE did not establish operational guidelines for Libby Dam for the 2001 Kootenai River white sturgeon spawning season. This decision was based on the Kootenai River White Sturgeon Recovery Plan; a minimum of an 80% water year is necessary for flows for sturgeon spawning to be provided.

Secchi disc measurements were made from May 1 through July 1 during mat sampling to provide a measure of turbidity during the spawning season. Measurements were made at rkm 229.8, 240.0, and 244.5, and daily measurements were averaged.

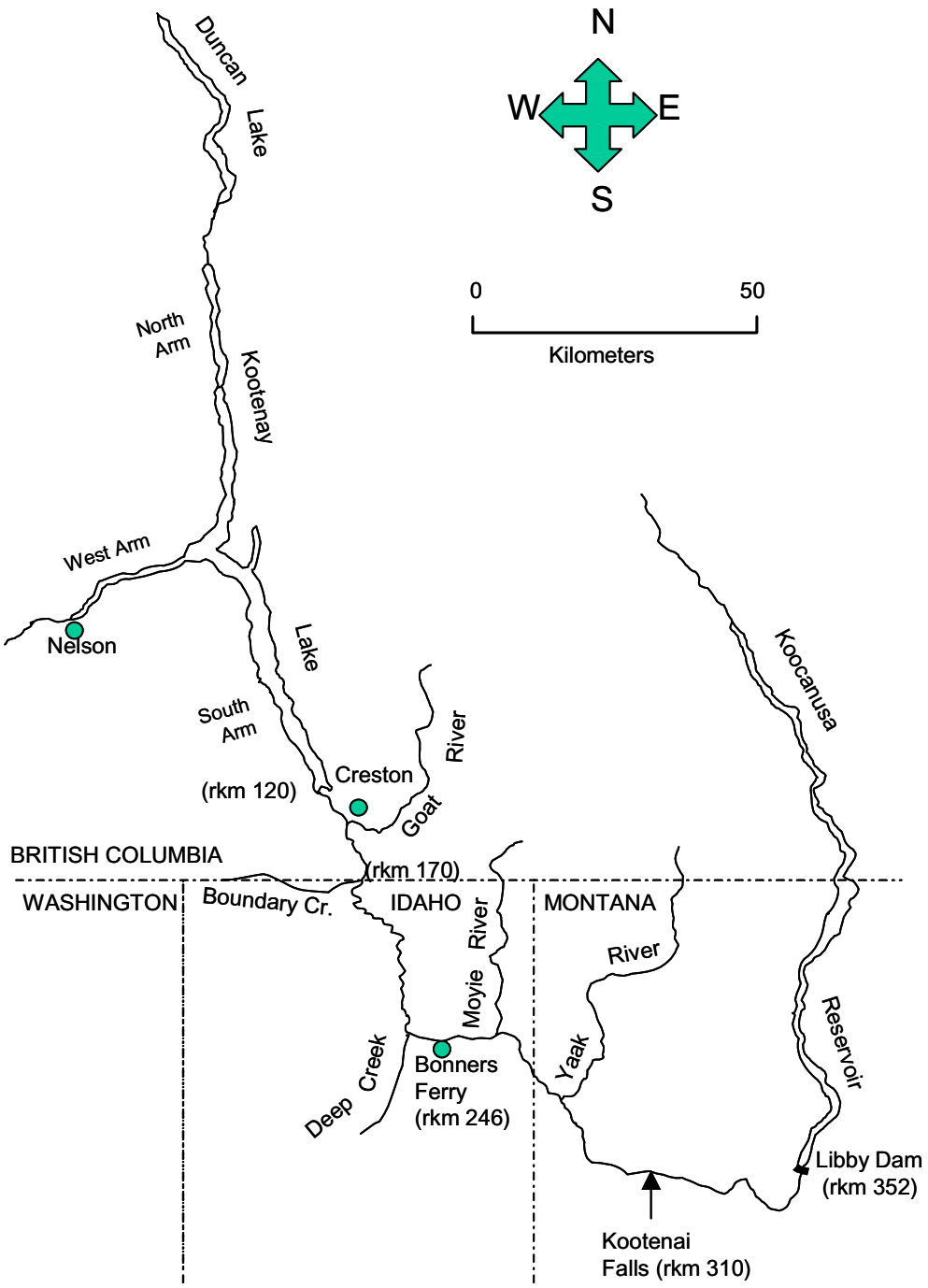

Figure 1. Location of the Kootenai River, Kootenay Lake, Lake Koocanusa, and major tributaries. The river distances from the northernmost reach of Kootenay Lake are in kilometers (rkm) and are indicated at important access points.

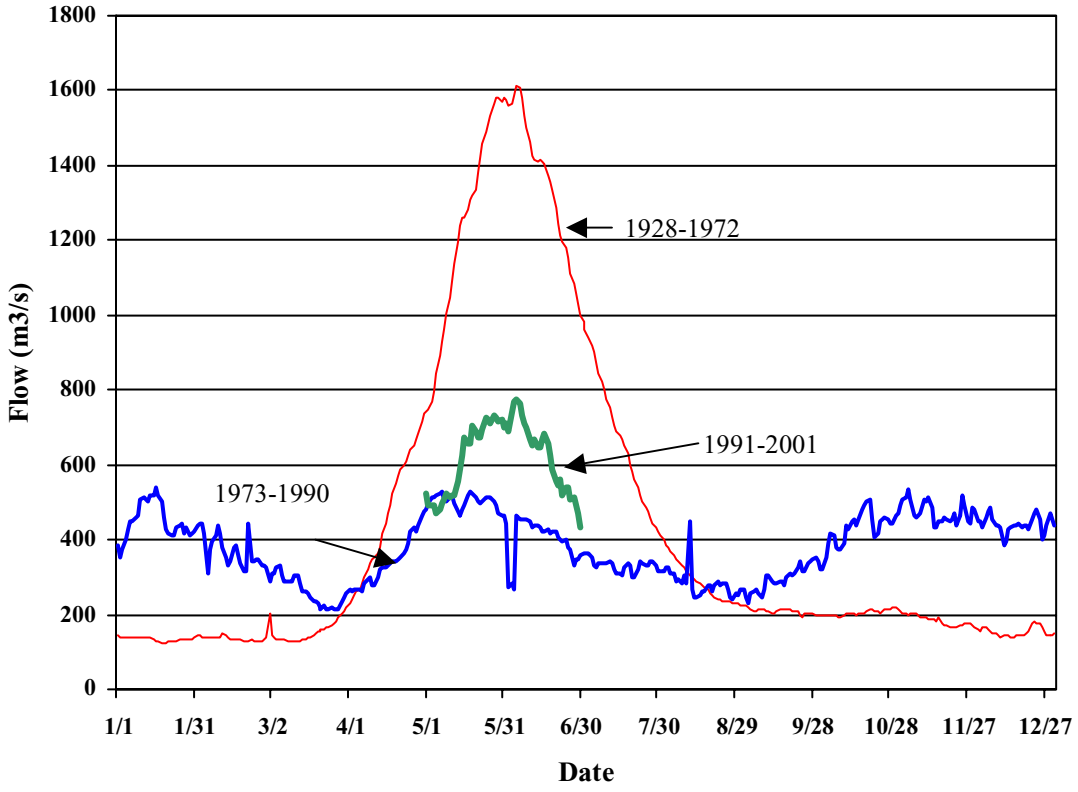

Figure 2. Mean daily flow patterns in the Kootenai River at Bonners Ferry, Idaho from 1928-1972 (pre-Libby Dam), 1973-1990 (post-Libby Dam), and 1991-2001 (post-Libby Dam with augmented flows).

Adult White Sturgeon Sampling

Adult white sturgeon were captured with rod and reel or setlines from March 6, 2001 to April 26, 2001, following the methods of Paragamian et al. (1996). Adult white sturgeon expected to spawn in 2001 were tagged with a depth sensitive radio transmitter and a sonic tag and monitored to determine movements during the spawning season (Paragamian et al. 1996).

Adult White Sturgeon Telemetry Methods

Boat Telemetry

Movement and migration of adult white sturgeon fitted with sonic and radio transmitters were monitored monthly by boat from the Kootenai River at Bonners Ferry to the river's delta at Kootenay Lake. The main objective was to locate late vitellogenic females and reproductive males migrating upstream to staging and spawning reaches. Each transmitter location was recorded to the nearest 0.1 rkm (0.061 mi). Effort to monitor sturgeon movement and activity

varied with season. Less effort was provided during winter months when most fish moved less frequently than in spring and autumn. Increased movement of tagged fish during the prespawning and spawning seasons required more frequent monitoring. Reaches above Copeland, Idaho (Figure 1) were monitored more intensively than downriver or Kootenay Lake, especially during the prespawning and spawning periods when mature sturgeon moved upstream.

Fixed-receiver Telemetry

Fixed location receivers provided us the opportunity to detect movement into specific locations at documented times of the day including the evening through morning hours. Three fixed-receivers were stationed between rkm 230.5 and 244.5. Site 1 was situated furthest downriver at mid-Shorty's Island (rkm 230.5). This downriver position was selected to detect fish movements into the Shorty's Island spawning reach (rkm 229.9 to 231.0) from downriver staging reaches. Site 2 was located at the Kootenai National Wildlife Refuge (rkm 237.5). Site 3 was located just upriver from Ambush Rock (rkm 244.5) on the south side of the Kootenai River at the end of a straight reach. This upriver location was chosen in 1999 in an effort to detect fish movements above Ambush Rock (rkm 244.4), eliminate background noise problems experienced at previous sites on the north side of the river, and avoid vandalism that occurred at the previous south-side sites in 1997 and 1998. This site is also the lower most reach of river with gravel and cobble substrate.

Each fixed-receiver station consisted of a scanning receiver [Advanced Telemetry Systems (ATS) model R2100], data logger (ATS model DCCII), 3-element Yagi antenna, and 12-volt deep-cycle battery to operate the system. Antennas were mounted on 1.8 m (6 ft) metal fence posts, horizontal to the river and affording a clear 180-degree view of the river. Selected sites were all on straight reaches to facilitate reception of the radio frequencies of potential male and female spawners programmed into the receivers. Data loggers were set to record only those frequencies matching tagged white sturgeon. Each receiver was also upgraded to conform to the depth sensitive tags to count signals per min in order to detect depth. A pattern-matching option was also selected to verify signals. A test radio tag was used to verify detection range and strength at each site.

Fixed-wing Telemetry

Two loop antennas were mounted on the wing struts of a Cessna 182 for fixed-wing aerial telemetry. Flights followed a route downriver from Bonners Ferry to Kootenay Lake at an altitude of 152 to 305 m (500 to 1,000 ft) above the river and speeds of 60 to 80 knots. Up to 13 preset radio frequencies of potential spawners were cycled through an ATS model R2100 scanning receiver and deleted as fish were detected. The frequency cycling rate was two to four seconds to facilitate maximum numbers of fish cycled (13) without sacrificing detection range. Locations were made to the nearest 0.1 rkm.

Depth Sensitive Radio Transmitters

Depth sensitive radio transmitters were used to aid in the determination of the vertical location of white sturgeon in the water column and to help identify where in the water column white sturgeon spawn. Depth sensitive radio transmitters are pressure responsive, and the

depth of the tag can be determined by the pulse frequency, with the frequency increasing with increasing depth. A stopwatch was used to determine the number of seconds for 10 pulses. The period reading was multiplied by 100 to give us the period reading in milliseconds. Three readings were made, and an average was used to determine depth. The average recorded pulses were entered into a regression equation, and the estimated transmitter depth was calculated. To provide more precise depth estimates for each fish, a regression equation was prepared for each radio, before attachment of the radio, by submersing the radio to known depths and counting pulses. The river depth at the fish location was determined using a Lowrance X15 depth finder and was recorded to the nearest foot (later converted to metric). Fish were located daily, and on occasion were followed for longer periods of time up to 8 h during daytime and nighttime hours. We used Chi-square analysis to detect any differences in night and day locations, above and below mid depth.

Artificial Substrate Mat Sampling

White sturgeon spawning was documented with artificial substrate mats (McCabe and Beckman 1990), herein mat. Mat densities in the spawning area were based on general densities of sturgeon monitored by telemetry in previous years. Adult white sturgeon densities were classified as high, medium, or low based on numbers of observations of sonic- and radio-tagged fish. Classifications are as follows; high—sturgeon were frequently located, medium—sturgeon were occasionally located, and low—sturgeon were seldom located (Paragamian et al. 1997). The length of the spawning reach was marked along the shoreline with flag material at each 0.1 km increment. We set a daily average of 54% (26) of the mats in low-density sections, 10.5% (5) in medium-density sections, and 23% (11) in high-density sections. We also set a daily average of 12.5% (6) in river kilometer sections with an unknown density of previous telemetry locations. These sites were selected to check for spawning activity in previously unsampled areas at either end of the spawning reach. An average of 48 mats (range 15 to 53) were deployed daily. Fewer mats were used in 2001 so more time could be allocated to telemetry. All eggs were removed from the mats, stored in labeled vials containing formalin or alcohol solution, and brought back to our laboratory. All viable eggs were staged by viewing at 120X under a dissecting microscope to estimate spawn date by the method of Beer (1981).

Experimental Release of Hatchery White Sturgeon Larvae

Hatchery reared white sturgeon larvae (7-21 d old) from the Kootenai Tribe of Idaho (KTOI) hatchery (technically the older aged sturgeon cannot be referred to as larvae because of their advanced development), were released into the Kootenai River to help resolve a “larvae to juvenile survival bottleneck” hypothesis. Survival of hatchery sturgeon is as high as 90% (Ireland et al. 2002); over a thousand eggs have been collected (Paragamian et al. 2001); yet, only one larval wild sturgeon has been captured. The fate of eggs and larvae within sand substrate is thought to be a contributing factor to the failure of satisfactory recruitment (a successful year class is defined by the Kootenai River White Sturgeon Recovery Team as the capture of 20 individual juveniles from a cohort). A second objective of the release was to determine if white sturgeon larvae could be captured by D-ring or ½ m net gear in the Kootenai River (as noted, only one white sturgeon larvae had been caught during ten previous years of study).

A total of 135,000 hatchery white sturgeon larvae were released from a boat at rkm 258.0 to 262.0 over cobble substrate. The first release was June 20, the next three releases

were on July 9, and the final release was on July 19. One boat was equipped with a single D-ring (for benthic sampling) and one ½ m net (subsurface); nets were deployed as passive gear. Sampling was limited to the first release. Sampling after the first release on June 20 began at 1045 hours and continued for 4 h. The first 2 h were at rkm 262, and the final 2 h were at rkm 259.1.

Larval Sturgeon Sampling

Larval white sturgeon sampling was conducted using ½ m nets at midwater column depths and at the surface, and D-ring nets at the bottom of the Kootenai River. Nets were either fished passively in the river current with a boat anchored in the thalweg, or nets were towed downstream at speeds exceeding the river current. Lead weights ranging from 2.7-9.1 kg (6-20 lbs) were attached to midcolumn and bottom nets in order to reach desired depths. Flow meters attached to the mouth of each net measured current velocity, which combined with total sampling time and respective net mouth dimensions gave the total volume of water sampled. Larval sampling took place at various times of the day between rkms 227.5 and 262.0 in June and July.

Juvenile White Sturgeon Sampling

Gillnetting

Four sizes of weighted multifilament gill nets with 1.3, 1.9, 2.5, and 3.8 cm (0.5, 0.75, 1, and 1.5 in) bar mesh were used to sample juvenile and young-of-the-year (YOY) sturgeon (Paragamian et al. 1996; Fredericks and Fleck 1996) during July and August 2001. Gill net sampling was conducted at index sites located between rkm 175 and 231. Gill nets were set during the day and checked every hour. All juvenile sturgeon were processed by methods cited in Paragamian et al. (1996).

Beam Trawling

Benthic trawls were carried out at randomly selected locations in the Idaho reach of the Kootenai River from rkm 170 to 229.5. Two types of benthic trawls were used to sample for juvenile sturgeon: a beam trawl with a mouth measuring 51 by 201 cm (20 by 79 in), and an otter trawl with a mouth measuring 61 by 213 cm (24 by 84 in). Trawls were towed in a downstream direction at speeds that would exceed the river current yet still allow the net to fish along the bottom of the river. Sampling was performed during daylight hours during July and August 2001. Benthic trawling provided the opportunity to sample the bottom of the river with gear that would be selective for age-0 and juvenile sturgeon.

RESULTS

Discharge, Water Temperature, and Secchi Measurements

Snow pack in the Kootenai River Basin was estimated at about 65% of normal in 2001. Outflow from Libby Dam was well below normal, and local inflows were also very low, <280 m^3/s

(10,000 cfs) (conversions to cfs are rounded to hundreds). Flows for white sturgeon spawning were not provided in 2001, because they were expected to be below the 80% of normal minimum for spawning flow requests in the Kootenai River White Sturgeon Recovery Plan (USFWS 1999). Libby Dam discharge from April 4 through July 1 was maintained at 113 m^3/s (4,000 cfs). Flow at Bonners Ferry on May 1 was at 311 m^3/s (10,980 cfs), gradually increasing to 383 m^3/s (13,530 cfs) on April 29. Flows peaked May 14 at 393 m^3/s (13,842 cfs), decreased slightly, then reached a second peak on May 25 at 383 m^3/s (13,515 cfs) and gradually decreased through June to only 155 m^3/s (5,470 cfs) by June 30 (Figure 3). Both peaks during May were due to local inflow. Water temperature varied between May and June with several rapid cooling periods (Figure 3). Temperature gradually increased from 6.3°C (43.3°F) on May 1 to 12.6°C (54.6°F) on May 28 but decreased and rose several times between May 29 and June 9 before reaching a peak of 16.8°C (62.2°F) on June 23. Temperature gradually decreased for several days after June 23 until June 27, then started increasing again, reaching 16.3°C (61.4°F) on June 30 (Figure 3).

Secchi measurements from May 1 through July 1 averaged 3.84 m, N = 131, SD = 0.91 m (12.58 ft, SD = 2.99 ft) and ranged from 1.52 m (5.00 ft) to 6.05 m (19.83 ft) (Figure 4).

Adult White Sturgeon Sampling

Seventy-five adult white sturgeon were captured with setlines, angling, and gill nets in 2001. Seventy-one adult white sturgeon were captured with 3,587.3 hours of angling and setlining effort between March 1 and August 31, 2001 (Table 1). Two of the adults (fish #'s 964 and 957) were small (140 and 135 cm total length) and were aged to the 1975 and 1969 year classes. Four more adult sturgeon were incidentally captured in juvenile gillnets during July and August 2001.

Sixty-eight (91%) of the 75 adult sturgeon captured were recaptures from previous years, and two were recaptures of fish originally caught in 2001 (Table 1). Catch per unit effort (CPUE) for adult white sturgeon caught by angling and setline gear was 0.086 and 0.017 fish/rod or setline h, respectively. Catch per unit effort in gillnets was 0.008 fish/gillnet h for adults captured during juvenile sampling (Table 1).

Table 1. Sampling effort and number of adult and juvenile white sturgeon caught by the Idaho Department of Fish and Game in the Kootenai River, Idaho, March 1, 2000 to August 31, 2001.

Gear Type	Hours of effort	Number of juvenile sturgeon caught (No. individuals)	Number of adult sturgeon caught (No. of recaptures)	Juvenile CPUE (fish/h)	Adult CPUE (fish/h)
Benthic Trawls	21.4	1(1)	0	0.0049	0
Gillnet	502.7	426(376)	4(2)	0.8474	0.008
Angling	139.2	0	12(11)	0	0.0862
Setline	3,587.3	2(2)	59(55)	0.0006	0.017
Total	4,250.6	429(379)	75(68)	0.1009	0.0176

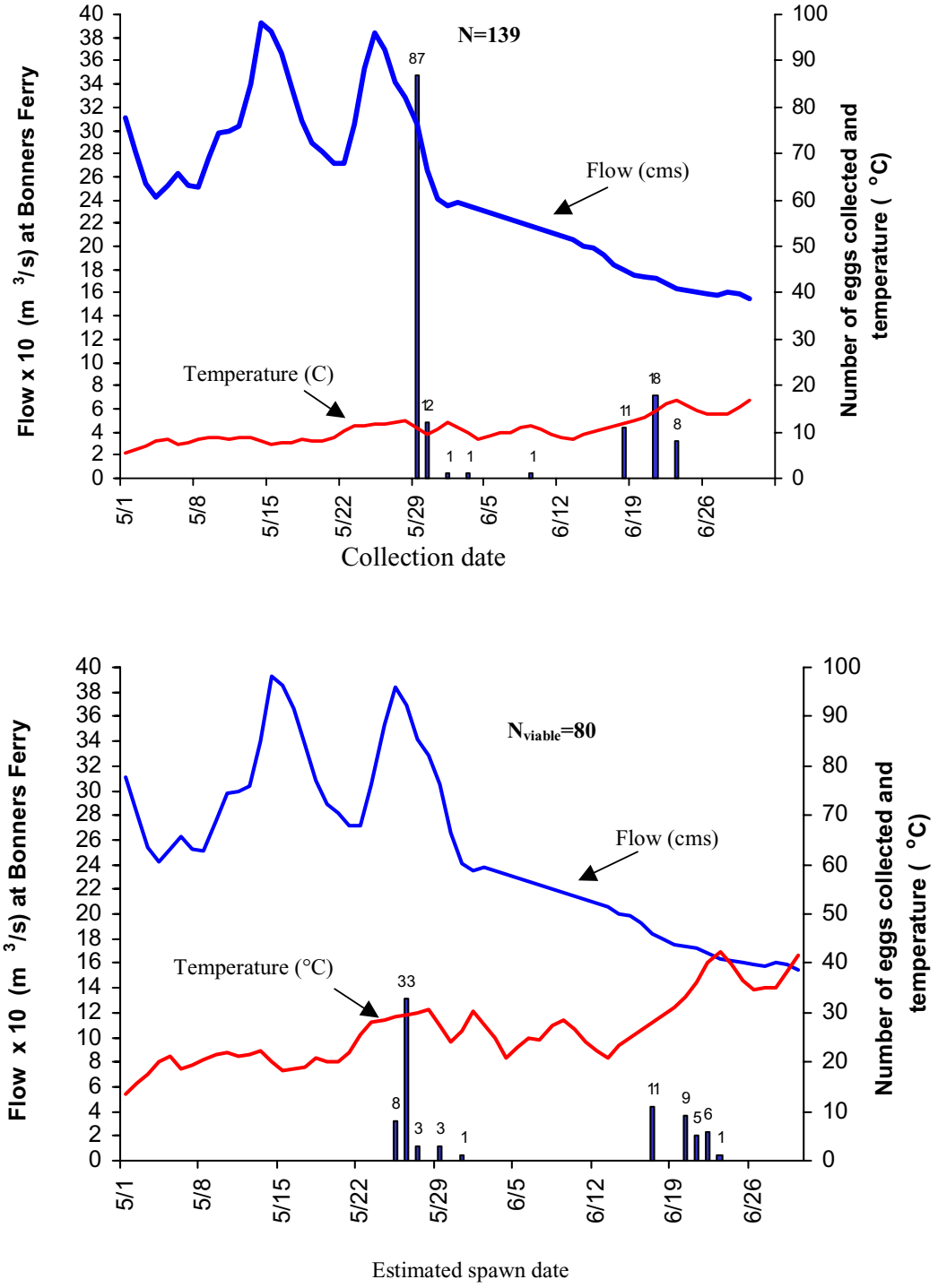

Figure 3. Top figure is collection date, number of eggs, temperature (°C), and flow (m^3/s), Kootenai River at Bonners Ferry, Idaho, 2001. Bottom figure is estimated spawn date, number of viable eggs, temperature (°C), and flow (m^3/s).

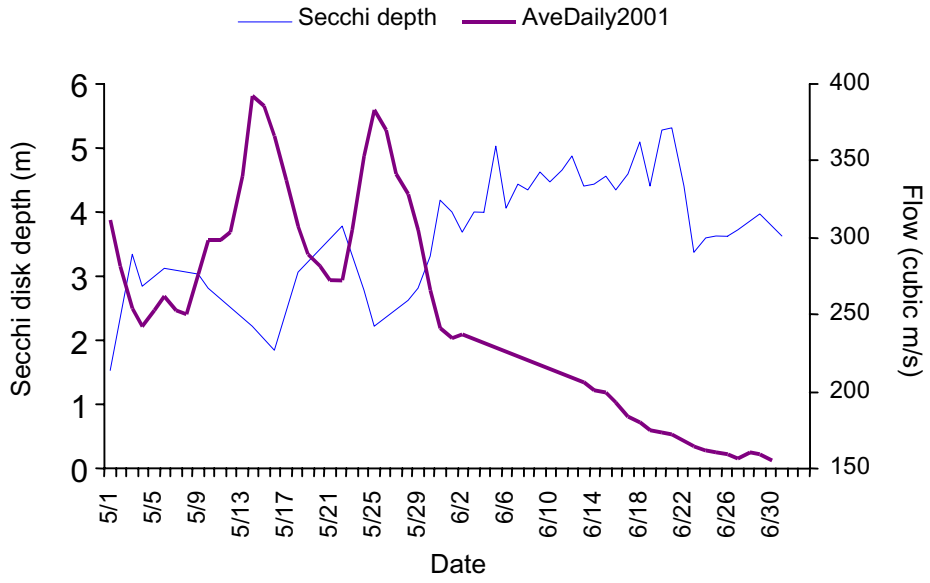

Figure 4. Secchi disk depth (m) and flow (m^3/s) in the Kootenai River near Bonners Ferry from May 1 to July 1, 2001.

Fifty-three biopsies were performed by the Idaho Department of Fish and Game (IDFG) on adult sturgeon during 2001 to determine sexual maturity stage of ovaries and testes (22 females, 26 males, 5 unknown) (Appendix 1). Sonic and depth sensitive radio tags were attached to four reproductively mature females and four mature male white sturgeon by IDFG during this effort in March and April; all fish were released. A fifth set of transmitters was added to another male caught by the KTOI in April during broodstock sampling, which occurred at the same time.

Adult White Sturgeon Telemetry

Migration of Monitored Sturgeon in 2001

We monitored the movements of 20 adult sturgeon from September 1, 2000 to August 31, 2001 (Figure 5, Table 2, and Appendix 2a, 2b, 3a, 3b, and 3c). These included fish in Kootenay Lake, BC, and the Kootenai River in Idaho and BC. The total included 13 females and 7 males. Eighteen of the 20 adult sturgeon were monitored in the Kootenai River (Table 2). Of these 20, 13 (ten females and six males) moved to the spawning reach from various staging or overwintering areas (Table 2 and Appendix 2a, 2b, 3a, 3b, and 3c). Seven fish (female fish numbered 284, 292, 958, 960 and males numbered 262, 694, and 956) were located in the spawning reach (rkm 228–246) during times when spawning was estimated to have occurred (Table 3). Another female (fish #812) was located the day after the latest collected eggs were estimated to have been spawned in the uppermost reach (rkm 244.6). All eight fish (females numbered 284, 292, 812, 958, 960 and males numbered 262, 694, and 956) are thought to have spawned (Table 2, “suspected spawners”) based on their development at capture and their movements during the spawning season.

Boat Telemetry

Boat telemetry for sturgeon locations was carried out from September 1, 2000 through August 31, 2001 (Figure 5). Ninety-three trips were made for a total of 274.3 h during which 403 white sturgeon locations were made. Most white sturgeon telemetry took place in May with 109.1 h of effort (Figure 5).

Table 2. Upriver locations of white sturgeon monitored in the Kootenai River from March 1, 2001 through August 31, 2001 (some fish moved out of Kootenay Lake, BC).

Fish #		Tagging Location (rkm)	Date Tagged	Highest rkm (date)		Last date located above rkm 225
Male	Female			>120<225	>225	
87[a,g]	—	205.0	4/19/01	221.0(5/15)	—	—
—	250	215.1	9/11/96	213.0(6/18)[b,e]	—	—
262[a,g,h]		205.0	4/10/01	—	237.5(5/25-27,30,6/3-4)	6/24
—	284[a,g,h]	215.5	3/14/01	—	237.5(5/2,15,23,25-27)	5/27
—	292[a,g,h]	215.5	3/15/01	—	237.5(5/16-17,20,27,29-30)	5/30
—	348	203.0	4/1/94	[b]	237.5(5/2,7,30,6/3)	[c]
394	—	215.6	3/11/99	215.0(3/16)[b,e]	--	—
—	409	215.5	3/19/97	[b]	236.5(6/18)[e,i]	6/18
—	625	215.4	3/24/95	[f]	--	--
635[g]	—	215.4	3/16/98	[b]	237.5(5/2,24,6/8)	[c]
694[a,g,h]	—	207.0	4/9/01	—	237.5 (5/26)	6/18
—	812[a,g,h]	214.6	4/23/01	—	244.6(6/24)	6/24
—	814	205.0	3/2/98	215.5(Mar-Aug)[b,d]	—	—
819	—	215.1	3/17/98	[b]	244.5(5/30)	[c]
—	882	215.6	3/17/99	—	226.3(5/7-8)[b]	7/19
—	890	215.6	3/24/99	[f]	—	—
—	931	122.5	10/4/00	202.2(5/30)[e]	—	—
956[a,g,h]	—	215.3	3/7/01	—	240.5(5/25)	6/18
—	958[a,g,h]	215.1	3/15/01	—	239.5(5/23)	5/28
—	960[a,g,h]	205.0	3/21/01	—	240.7(5/24)	5/27
n=7	n=13			Combined (n=20)		
n=3	n=5			Suspected Spawners (n=8)		
n=4	n=8			Non-spawners (n=12)		

[a] These fish were tagged with depth tags.
[b] These fish overwintered in this section.
[c] These fish never dropped below river kilometer 225.
[d] These fish had no locations in 2001.
[e] These fish had only one location from 3/1/01 through 8/31/01.
[f] These fish made no upriver movements out of Kootenay Lake in 2001.
[g] These fish were expected spawners (assessed by their development in 2001).
[h] These fish were suspected spawners (assessed by their movements in 2001).
[i] This fish spawned in 1997. This location suggests spawning in 2001, but is inconclusive.

Table 3. White sturgeon adults tracked to sections of the Kootenai River, Idaho, where sturgeon eggs were spawned (back calculated to estimated spawning date), within 24 h preceding spawning, 2001.

Location	Spawn date[a]	Fish number	
		Males	Females
Lower Shorty's Island (rkm 227-229.5	None	None	None
Middle Shorty's Island (rkm 229.6-231.5)	May 25, May 26, May 27, May 29, May 31, June 17, June 20	262, 694, 956	284, 292, 960, 958
Wildlife Refuge (rkm 234.0-240.0)	None	None	None
Town (>240.0)	June 20, June 21, June 22, June 23	None	None

[a] This assumes that eggs were spawned in the same river reach where they were collected.

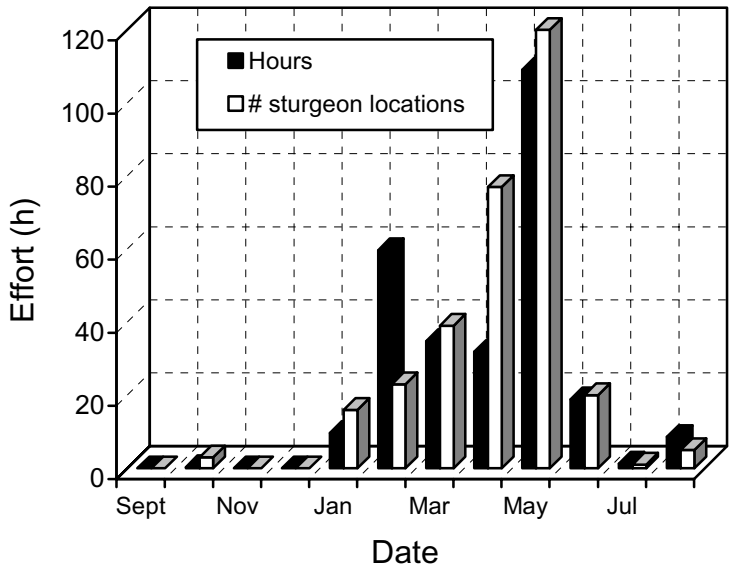

Figure 5. Telemetry effort (hours) and number of times white sturgeon were located monthly from September 1, 2000 to August 31, 2001, Kootenai River, Idaho. Telemetry effort and white sturgeon locations share the same axis.

Fixed Receiver Telemetry

Fixed site 1 logged data April 27 through June 14. Site 2 operated May 2 through June 15. Site 3 collected data April 30 through June 15. These dates corresponded to the period of upriver movements of spawning fish as noted by current boat, aerial, and fixed-station telemetry. Flows had also dropped to a low level (<240 m^3/s [8,462 cfs]) by June 2 and continued to drop the remainder of the month (155.3 m^3/s [5,475 cfs]). The fixed receivers missed a late (June 24) upriver surge (to rkm 244.5) by one female (fish #812). This fish had already been located five times above rkm 243.5 (May 15–25) and was believed to have spawned and be dropping downriver of the spawning reach. The only locations discussed in our analysis are those verified by boat or aerial telemetry or those occurring at more than one fixed station. The 3-element Yagi antennas detected the movements of seven fish past one or more of the three fixed stations. This included four females (fish numbered 284, 292, 958, and 960) and three males (numbered 262, 694, and 956).

No verifiable locations were detected at the upriver station (site 3 at Ambush Rock, rkm 244.5), although one tagged female (#812) made it near this site when the receiver was operational. All verifiable locations were near the Shorty's Island site (site 1, rkm 230.3) or the Refuge site (site 2, rkm 237.5). All four females (numbered 284, 292, 958, and 960) and three males (numbered 262, 694, and 956) were detected at site 1 and site 2.

Fixed-wing Telemetry

Fixed-wing flights took place September 5, 2000 through May 31, 2001. All flights occurred in conjunction with tracking flights for tagged bull trout *Salvelinus confluentus* and rainbow trout *Oncorhynchus mykiss*. Five flights were made searching for white sturgeon from Bonners Ferry to Kootenay Lake. In approximately 6.4 h of flying concentrating on sturgeon, 21 sturgeon locations were made. This accounted for 53.9% of the sought after fish tags. Ten different fish were located. These included ten expected spawners (four females numbered 284, 812, 958, and 960 and six males numbered 87, 262, 292, 635, 694 and 956). Locations were recorded to the nearest 0.1 rkm. The majority of the flying occurred from Bonners Ferry (rkm 245.0) to the Canadian border (170.0), but also down to the Kootenai River Delta (rkm 113.0 to 122.0).

Depth Sensitive Radio Transmitters

Depth sensitive radio transmitters were attached to nine white sturgeon expected to spawn in 2001. The fish were captured in staging areas and in the spawning reach during the months of March and April. Four males and five females were pinpointed using sonic telemetry, and location was recorded to the nearest 0.1 rkm. Our objective to determine where in the water column white sturgeon spawn was not achieved; however, our intense monitoring of sturgeon with transmitters revealed some behavioral characteristics of interest.

A total of 301 radio contacts were made on the nine fish with depth sensitive radio transmitters. Of these contacts, 168 (56%) of them were made when the radio transmitter was between the depths of three and nine m (9.8-29.5 ft). In addition, 77% (233) of the total contacts were made in the bottom one-third of the water column (Appendix 4). Some white sturgeon with

depth sensitive transmitters demonstrated evidence of acute sensitivity to an approaching boat. For example, when our telemetry boat approached female #7248, she immediately moved away from the boat, while others frequently allowed us to motor above them without flight. A second sturgeon was recorded frequently diving to deeper water at the approach of a boat. It was not uncommon for white sturgeon to follow the contour of the river bottom as they moved, but they were usually suspended 2-3 m (6.6-9.8 ft) above the bottom (Appendix 5). White sturgeon also showed an apparent preference for suspending in the water column just below sand dunes (Appendix 6). It is not known if they were in this position for energy conservation or feeding. After continuous periods of telemetry effort, rates of movement were determined for a few individual fish. For example, after a two-hour tracking period, fish #284 averaged 1.69 m/min (5.5 ft/min), with a single movement of 7.51 m/min (24.6 ft/m); at times, other fish moved too fast to calculate speed.

White sturgeon monitored during the spawning season demonstrated a wide range of activity within the water column but provided minimal information regarding actual spawning. For example, during the evening of May 25, female #284 traveled over 700 m from about rkm 235.9-236.6 and came within several m of the surface several times (Appendix 7); depth was from about 6-12 m. On this same evening, two male white sturgeon moved very little. It is not known if any of these fish were spawning, since no eggs were found in the vicinity. We were unable to detect a difference in location within the water column between night and day telemetry ($p = 0.769$).

Artificial Substrate Mat Sampling

We sampled a total of 67,753 h or 2,823 mat d in the Kootenai River during white sturgeon spawning in 2001 (Table 4). Sampling with mats began May 1 and ended June 29, 2001. A total of 139 sturgeon eggs was collected (Figure 3 and Appendix 8). A single mat on May 29 held 86 eggs comprising 62% of the total collection (Appendix 8 and 9).

Sampling mats collected eggs within three of 11 different geographic river sections sampled in 2001 (Table 4 and Appendix 8 and 9). The Middle Shorty's reach (rkm 229.6-231.5) produced the most eggs (113) with 389 mat d of effort. The U.S. Highway 95 section (rkm 244.7-246.6) produced 22 eggs with 315 mat d of effort. The Refuge section (rkm 234.8-237.5) produced four eggs with 939 d of mat effort. Depth of artificial substrate mat placement ranged from 0.61-23.2 m (2-76 ft) for all mats (Table 4). Mats that collected eggs ranged from 3.1-11.9 m (10-39 ft) in depth, averaging 8.1 m (24 ft) (Appendix 8 and 9). Near surface velocities (0.2 depth) at 14 egg collection sites ranged from 0.15-1.30 m/s (0.5-4.5 ft/s) and averaged 0.54 m/s (1.8 f/s) (Appendix 8 and 9). Velocities near the river substrate (0.8 depth) at the egg collection sites ranged from 0.18-1.30 m/s (0.6-4.3 ft/s) and averaged 0.50 m/s (1.6 ft/s). Mean column velocity at egg collection locations ranged from 0.19-1.32 m/s (0.6-4.3 ft/s) and averaged 0.52 m/s (1.7 ft/s) (Appendix 9).

Eighty (58%) of the 139 white sturgeon eggs collected in 2001 were viable. Egg-development ranged from stage 12 to stage 24 (less than 1 h to 95 h old) (Appendix 9). Based on ages of viable eggs and the dates of egg collection, we estimated that white sturgeon spawned during at least 10 days in 2001 (Figure 3 and Appendix 9). The first spawning events were estimated to have occurred on May 25 with spawning continuing on four of the next six days until May 31. The next events were estimated to have occurred over two weeks later on June 17, June 20, June 21, and June 22, with the last day of spawning occurring June 23.

Table 4. Location (rkm), depth (m), effort, and white sturgeon egg catch by standard artificial substrate mats, Kootenai River, Idaho, 2001.

Geographical description	River location (rkm)	Depth range (m)	Total sample hours (days)[a]	Number white sturgeon eggs
Rock Creek	213.0-216.0	5.2-16.2	2,279.9	0
Lower Fleming Ck.	222.6-224.5	5.5-12.5	1,568.3	0
Lower Shorty's Island	227.0-229.5	4.3-21.6	11,974.1	0
Middle Shorty's Island	229.6-231.5	3.7-20.7	9,340.0	113
Upper Shorty's Island	231.6-233.4	4.9-10.7	6,497.8	0
Myrtle Creek	233.5-234.7	4.0-12.8	5,616.9	0
Refuge	234.8-237.5	3.1-18.3	22,533.7	4
Deep Creek[b]	237.6-240.5	No sampling	No sampling	No sampling
Hatchery[b]	240.6-243.9	No sampling	No sampling	No sampling
Ambush Rock	244.0-244.6	5.2-6.4	162.6	0
US Hwy 95	244.7-246.6	0.6-7.6	7,565.2	22
Upper Pump Station	246.7-247.7	9.1	47.7	0
Moyie River	258.5	5.2-6.7	167.1	0
All Sections	213.0–258.5	0.6-21.6	67,753.3	139

[a] One mat sample is equal to the time a mat is in the river before it is pulled and checked.
[b] Sampled in previous years, but eggs were never collected.

Observations of a Suspected Spawning Pod of White Sturgeon

On June 19 at about 1400 h, two biological aides observed ten white sturgeon on a shallow gravel bar in the vicinity of rkm 245.5 and 245.7. The water depth was between 2 m (6 ft) and 4 m (12 ft). Water clarity was excellent with a Secchi disc reading of over 5.8 m (19 ft). A single fish was observed first; as the biological aides approached, the fish turned and swam in front of the boat. A second sturgeon was observed soon afterward on the bottom of a nearby sand bar. The biological aides were able to approach within a meter (3.3 ft) of the fish until it swam away a few moments later. After it swam off, they observed a pair of adult sturgeon swimming side by side. These fish were believed to have been 1.8-2.1 m in length (6-7 ft). As the biological aides continued upstream, they saw seven to eight more sturgeon before reaching the Burlington, Northern and Santa Fe Railroad bridge. After they reached the railroad bridge, they turned off the boat motor and drifted downstream observing the sturgeon. This drifting procedure was repeated several times. The sturgeon were in water as shallow as 0.6 m (2 ft) and swimming in pairs or in groups of seven or less. On subsequent days, the sturgeon were observed and videotaped by the KTOI and other members of IDFG between the railroad bridge and the I-95 Bridge.

We cannot be certain the white sturgeon observed during the observation periods were in the act of spawning, but on June 21 and 22, 22 eggs were collected between rkm 245.1 and 245.7 (Appendix 9). The estimated spawn dates for these eggs were June 20, 21, 22, and 23.

Experimental Release of Hatchery White Sturgeon Larvae

The KTOI released 135,000 hatchery white sturgeon larvae during five releases from June 20 through July 19, 2001 at about rkm 262.2 (Table 5). Larvae were released at the surface. Sampling with ½ m nets and D-rings resulted in a total catch of 97 larvae about 10 min after the first experimental release (sampling occurred before and after the release). Eighty-eight recaptures were made by the D-ring sets near the river bottom and nine by ½ m nets midcolumn at rkm 262.0.

Larval Sturgeon Sampling

White sturgeon larvae sampling was carried out between June 20 and July 20, 2001. We made 425 tows and sets with ½ m and D-ring nets between rkm 227.5 and 262.0 in the Kootenai River. No wild white sturgeon larvae were caught during 2001.

Table 5. Estimated number of hatchery white sturgeon larvae released, release date, and catch by D-ring or ½ m net.

Release date	Estimated number released	D-ring catch bottom	1/2 m net catch	
			Surface	Mid-water
June 20, 2001	30,000	88	0	9
July 9, 2001	35,000	0	0	0
July 9, 2001	45,000	0	0	0
July 9, 2001	15,000	0	0	0
July 19, 2001	10,000	0	0	0
Total	**135,000**	**88**	**0**	**9**

Sampling with ½ m nets and D-rings, including the effort during the hatchery release, was accomplished primarily during the day. Half-meter nets at the surface sampled 37,410 m^3 of water in 10.4 h, captured no non-sturgeon fish larvae, no non-sturgeon eggs, and no wild white sturgeon. Half-meter nets at midcolumn depths sampled 85,105 m^3 in 23.6 h, captured 15 non-sturgeon larvae, and no non-sturgeon eggs. D-ring nets set at the river bottom sampled 653,310 m^3 in 181.5 h, captured 17 non-sturgeon larvae, and two non-sturgeon eggs. Duration of sets ranged from 1 min to 1 h 32 min and averaged 30.7 min.

Juvenile White Sturgeon Sampling

We expended 503 hours of gillnet sampling effort during July and August 2001 to capture 426 juvenile white sturgeon (Tables 1, 6, 7 and Appendix 10 and 11). In addition, several hatchery released juvenile sturgeon were captured incidentally during hoop net effort for burbot in a companion study (Kozfkay and Paragamian, in progress), and another juvenile hatchery sturgeon was captured in a beam trawl tow on July 23. Catch per unit effort for juvenile sturgeon captured by gillnet was 0.85 juveniles/h. Most of the juvenile sturgeon captured by gillnet by IDFG in 2001 were hatchery progeny (Table 6). Eight of these gillnet captures were wild, of which one was a recapture. Five of the wild juvenile white sturgeon were recruits from flow test years (Appendix 10). Two of these fish (fish numbered 7911 and 7916) were from the 1995 year class, two (fish numbered 7906, 7927) from 1996, and one (fish #7928) from 1997

year class. Two of the remaining wild juvenile fish were from 1994 (fish numbered 7892, 7920), and the recaptured wild juvenile fish (fish #5383) was from an unknown year class. Finally, two wild juvenile sturgeon were captured during adult setlining in April; one was of the 1991 year class (fish #7891) (Table 1).

Relative Weights of Adult and Juvenile White Sturgeon

We calculated fork length (FL) relative weight (Beamesderfer 1993) for 61 adult white sturgeon captured in March and April 2001. Fork length relative weight for adult white sturgeon ranged from 64 to 161 and averaged 94 (SD = 15). Calculated FL relative weight for 208 juvenile hatchery white sturgeon of the 1999 brood year captured during July and August 2001 ranged from 28.5 to 154.8 and averaged 91.9 (SD = 16.3).

Table 6. Idaho Department of Fish and Game juvenile white sturgeon gill net sampling effort by mesh size for July and August 2001.

Gillnet Mesh Size	Number Of Sets	Hours of Effort	Number of Adults Captured	Number of Juveniles Captured	Sturgeon Catch Per Unit of Effort
1.3 cm / 0.5” bar	40	75.1	0	24	0.32
1.9 cm / 0.75” bar	44	100.8	0	69	0.68
2.5 cm / 1” bar	48	108.2	0	88	0.81
3.8 cm /1.5“ bar	102	218.6	4	245	1.14

Table 7. Vital statistics of juvenile hatchery white sturgeon recaptures from summer 2001 gill net sampling by the Idaho Department of Fish and Game.

	Statistic	FL (cm)	TL (cm)	WT (kg)
	Average	24.70	28.20	0.082
	Standard deviation	1.37	1.43	0.009
Recaptures	Minimum	23.20	26.10	0.07
N = 416	Maximum	25.90	29.10	0.09

DISCUSSION

The 2001 monitoring and evaluation study season for Kootenai River white sturgeon presented several unexpected circumstances. The lower than normal snow pack precluded a request for mitigation flows for white sturgeon spawning and rearing. However, despite the unusually low flows, white sturgeon spawning was still documented, primarily in the lower portion of the spawning reach (rkm 229.6-231.5) as expected (Paragamian et al. 2002). Documented spawning first took place in late May and extended for only a week (May 25-31). Water temperature then decreased more than 0.8°C (1.4°F), and white sturgeon ceased spawning. Decreases in water temperature in the Kootenai River of 0.8°C (1.4°F) or more apparently cause white sturgeon to cease spawning (Paragamian and Wakkinen 2002). However, well after spawning had ceased and all but one white sturgeon with transmitters had left the main spawning reach, water temperature increased rapidly from 8.3-16.9°C

(46.9-62.4°C). The increase in water temperature may have stimulated a second unexpected event; some of the remaining adults spawned at rkm 245.5-246.7. Movement to this reach of river and spawning over gravel substrate was confirmed only in 1991 and 1992 (Paragamian et al. 2001).

A third extraordinary event was the capture of seven wild juvenile white sturgeon representing cohorts from 1994-1997. No wild white sturgeon juveniles from mitigated flow years were captured in 2000, and only four known wild sturgeon recruited from mitigated flow years were caught during previous years of study (Appendix 10).

The experiment to determine if sand substrate (habitat) limits the survival of wild white sturgeon larvae was continued in 2001 with a larval release of 135,000 hatchery larvae over cobble and gravel substrate at the Hemlock Bar reach (rkm 259.1-262.0). Ninety-seven larvae were recaptured with D-ring and ½ m nets during sampling immediately after the release. However, electrofishing within and below this same reach did not produce any white sturgeon young (Walters, in progress). Similar results were obtained in 2000.

The capture of hatchery reared larvae immediately after their release during 2000 and 2001 indicated our sampling gear is adequate to capture wild larvae providing they are present. Studies on the Columbia River have shown D-rings and ½ m nets to be useful in measuring the abundance of white sturgeon larvae (McCabe and Beckman 1990; McCabe and Tracy 1994; Parsley et al. 1993; Parsley and Beckman 1994). Sampling at night may also be necessary to ensure that we are not biasing our studies. Auer et al. (2002) found lake sturgeon *A. fulvescens* larvae in the Sturgeon River, Michigan, moved almost exclusively at night. These findings are supported by laboratory studies of white sturgeon by Brannon (1984). Due to our capture of larvae in sampling gear, we are confident the reason we failed to capture white sturgeon larvae is that their numbers are low. Sampling at night will provide another measure to determine the presence of sturgeon larvae.

The use of depth sensitive radio tags may help to determine where in the water column white sturgeon spawn. We believe future efforts should be directed at monitoring fewer fish over longer periods near deposited eggs. In 2001, we spent our time finding all telemetered fish; each day of the season and a great deal of time was expended in the search. In the future, we will direct our effort toward fewer individuals, which may provide more detailed information on individual fish movements and increase our chances of documenting behavior during actual spawning events.

We examined white sturgeon spawning events during the years 1994 through 2000 and compared them to daily average flow and daily average temperature at Bonners Ferry for each event (Paragamian and Wakkinen 2002). We found white sturgeon often spawned during decreasing flows, and the number of events each year ranged from as few as nine to as many as 20, with the number of days during the spawning period ranging from 17 to 31 days. The most consistent year of Kootenai River white sturgeon spawning was 1996 when spawning was detected during 18 of 19 days; flow ranged from 891-1,259 m^3/s (31,465-44,461 cfs) and averaged about 1,131 m^3/s (~40,000 cfs) for the first 11 events before there was a day of undocumented spawning. Average daily temperature during spawning ranged from 7.5-14°C (45.5-57.2°F), with the highest probability of spawning (48%) at the 9.5-9.9°C (49.1-49.9°F) range (Paragamian and Wakkinen 2002). However, despite our improved understanding of spawning events, there has been little success at measuring recruitment of young white sturgeon from mitigated flow years; with the available data, the present level of recovery is still unknown (Paragamian and Wakkinen 2002; Paragamian et al. 2002).

Flow was also an important variable affecting sturgeon spawning. Average daily flow for spawning events ranged from 141-1,265 m^3/s (4,979-44,673 cfs) but most (63%) spawning took place above 630 m^3/s (22,248 cfs) (Paragamian and Wakkinen 2002). Our analysis suggests flows for optimum white sturgeon spawning in the Kootenai River should be held above 630 m^3/s (22,248 cfs), an ideal temperature range of 9.5-12°C (49.1-53.6°F), and duration of 42 d, based on recommendations in the Kootenai River White Sturgeon Recovery Plan (USFWS 1999). As previously noted, the most consistent spawning took place at an average of about 1,131 m^3/s (~40,000 cfs). However, of the two variables, temperature is the most difficult to control.

RECOMMENDATIONS

1. As soon as water temperature reaches 7°C (43°F) after April 1, provide 425 m^3/s (15,000 cfs) flow with stable or increasing temperature to initiate and maintain spawning migration of Kootenai River white sturgeon.

2. Once water temperatures of 8°C to 10°C (46°F to 50°F) are reached, provide minimum flows of 630 m^3/s (22,248 cfs) for 42 d (as prescribed for spawning and rearing in the Kootenai River White Sturgeon Recovery Plan) at Bonners Ferry to stimulate spawning and optimize egg/larval survival of Kootenai River white sturgeon.

3. Evaluate the role substrate composition (sand vs. cobble substrate) may play in the failure to recruit white sturgeon juveniles from successful spawning events.

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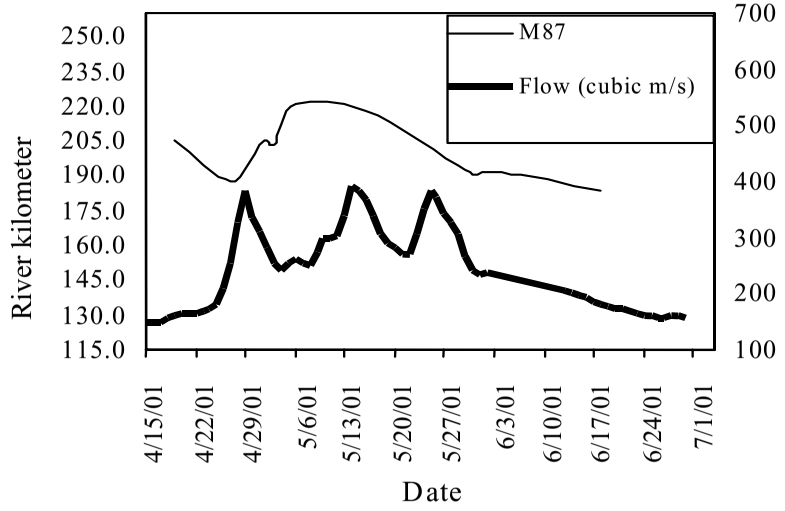
APPENDICES

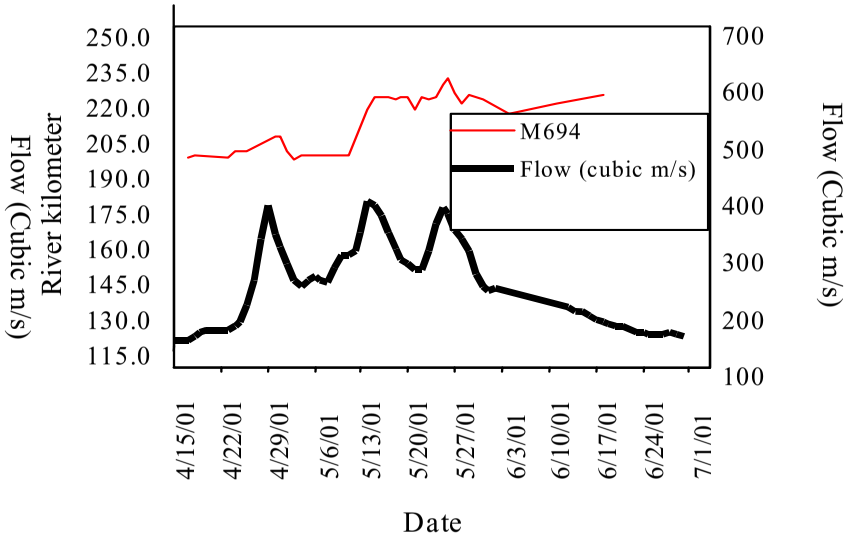
Appendix 1. Sexual development of white sturgeon sampled and biopsied by IDFG in the Kootenai River, Idaho, 1989 through 2001.

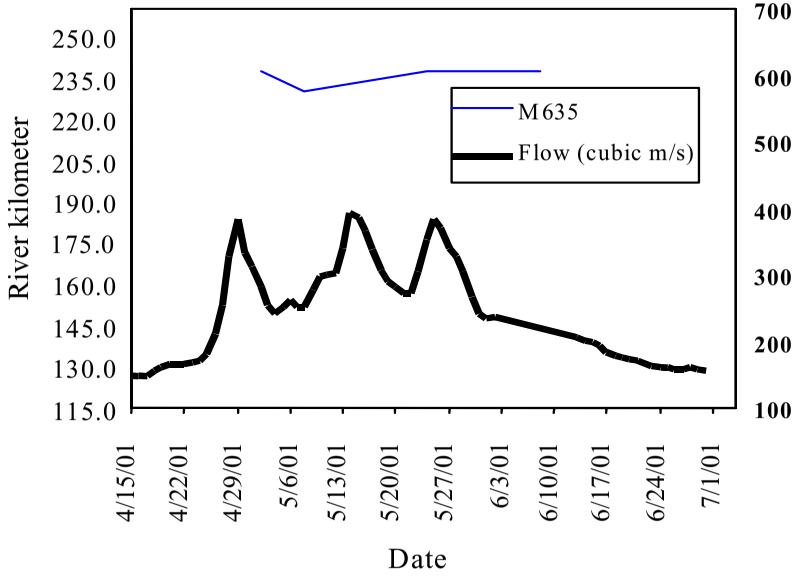
Categories of sexual development		Percent (number) of sample by year												
Category/ Sex	**Description of development**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995[a]**	**1996[a]**	**1997**	**1998**	**1999**	**2000**	**2001**
0/Unknown	Gonad undifferentiated or not seen	34 (61)	14 (16)	10 (4)	4 (1)	16 (6)	26 (15)	9 (2)	12 (5)	10 (6)	13 (6)	9 (4)	10 (6)	19 (10)
1/Female	Previtellogenic: No visual signs of vitellogenesis; eggs present but have avg. diameter <0.5 mm	13 (23)	12 (13)	8 (3)	11 (3)	5 (2)	5 (3)	9 (2)	8 (3)	17 (10)	15 (7)	9 (4)	8 (5)	21 (11)
2/Female	Early vitellogenic: Eggs are cream to gray; avg. diameter 0.6-2.1 mm	6 (12)	7 (8)	5 (2)	4 (1)	10 (4)	2 (1)	0	5 (2)	0	15 (7)	2 (1)	7 (4)	6 (3)
3/Female	Late vitellogenic: Eggs are pigmented & attached to ovarian tissue; avg. diameter 2.2-2.9 mm	5 (10)	5 (5)	11 (4)	12 (3)	8 (3)	5 (3)	0	3 (1)	2 (1)	5 (2)	5 (2)	2 (1)	2 (1)
4/Female	Ripe: Eggs are fully pigmented & detached from ovarian issue; avg. diameter 3.0-3.4 mm	2 (3)	5 (5)	0	0	3 (1)	14 (8)	27 (6)	15 (6)	10 (6)	2 (1)	24 (10)	15 (9)	9 (5)
5/Female	Spent: Gonads are flaccid & contain some residual fully pigmented eggs	3 (5)	1 (1)	3 (1)	0	0	0	5 (1)	0	0	0	0	0	0
6/Female	Previtellogenic with attritic oocytes: Eggs present but have an average diameter <0.5 mm; dark pigmented tissue present that may be reabsorbed eggs	2 (3)	0	0	0	0	0	0	5 (2)	3 (2)	0	0	0	0
R/Female	Reabsorbing eggs	0	0	0	4 (1)	0	0	0	0	0	0	0	0	0
7/Male	Non-reproductive: Testes with translucent smoky pigmentation	3 (5)	27 (30)	34 (13)	38 (10)	8 (3)	19 (11)	23 (5)	30 (12)	23 (14)	13 (6)	35 (15)	29 (18)	19 (10)
8/Male	Reproductive: Testes white with folds & lobes	32 (58)	28 (31)	18 (7)	27 (7)	47 (18)	29 (17)	27 (6)	20 (8)	35 (21)	37 (17)	16 (7)	29 (18)	24 (13)
9/Male	Ripe: Milt flowing; large white lobular testes	0	1 (1)	3 (1)	0	0	0	0	0	0	0	0	0	0
S/Male	Spent: Testes flaccid; some residue of milt	0	0	8 (3)	0	3 (1)	0	0	3 (1)	0	0	0	0	0

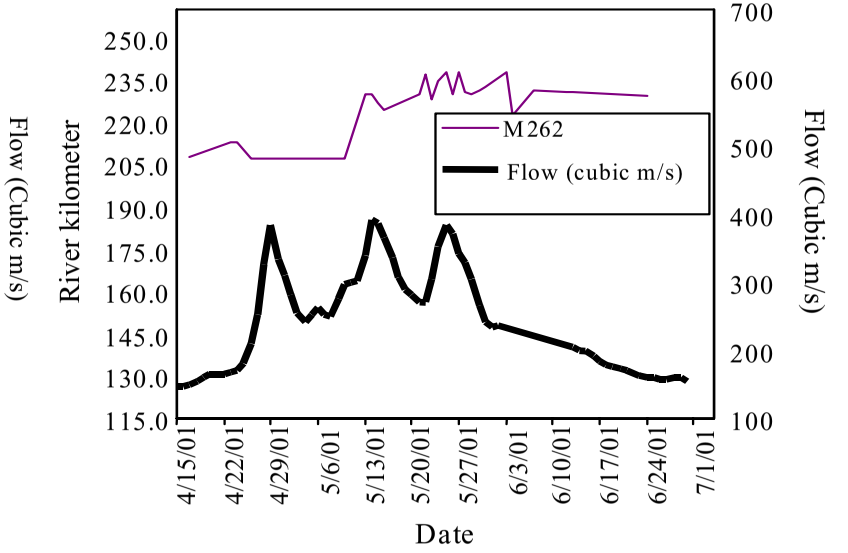
[a] Surgeries were carried out on fish that externally appeared to be candidates for spawning.

Appendix 2A. Migration and flow (m^3/s) for four of six adult male white sturgeon, three of which are believed to have spawned in the Kootenai River, Idaho in 2001.

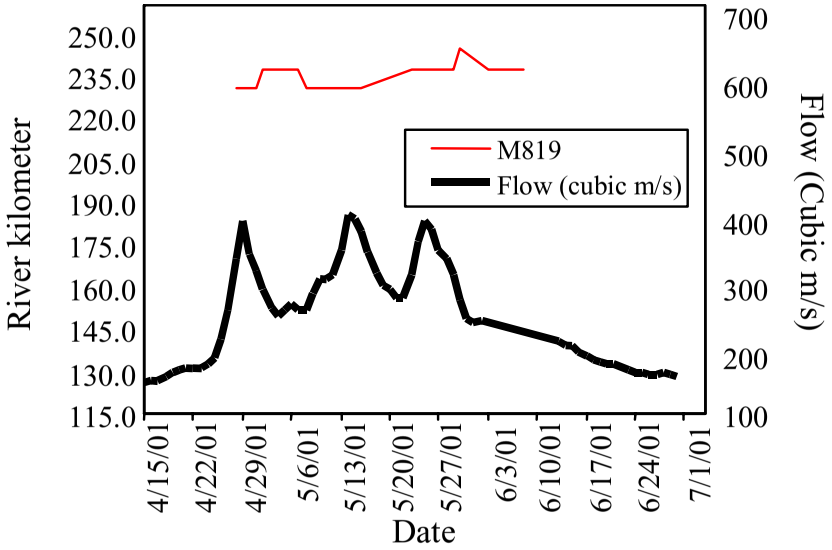


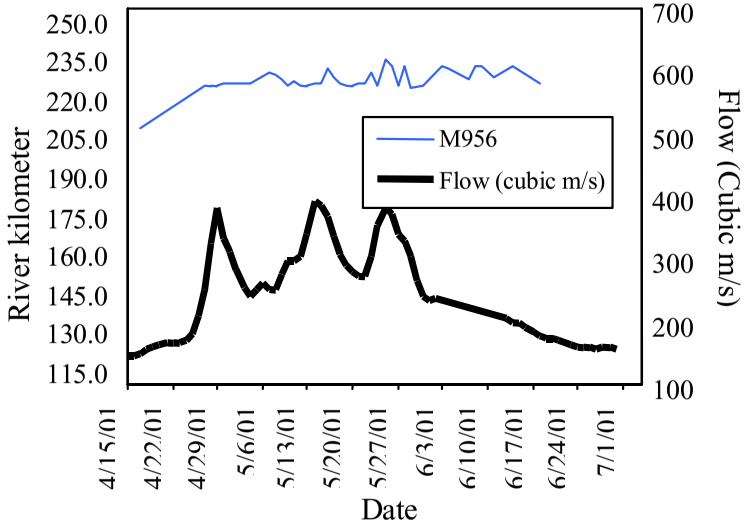




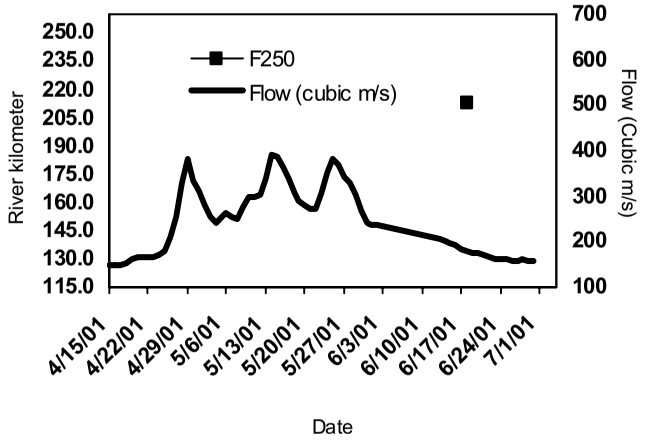


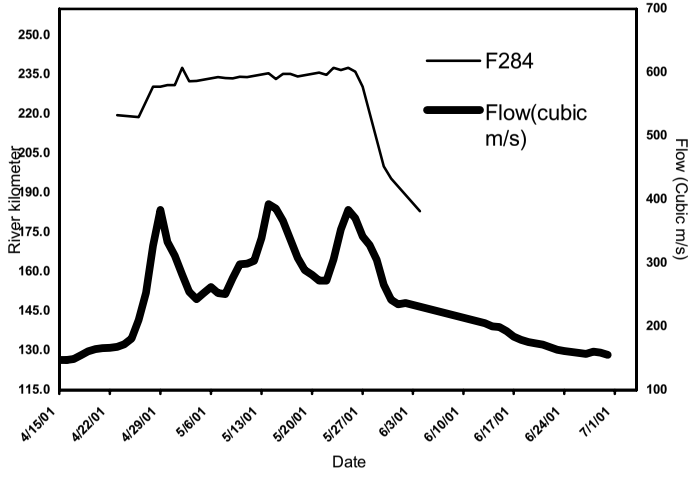
Appendix 2b. Migration and flow (m^3/s) for two of six adult male white sturgeon, three of which are believed to have spawned in the Kootenai River, Idaho 2001.

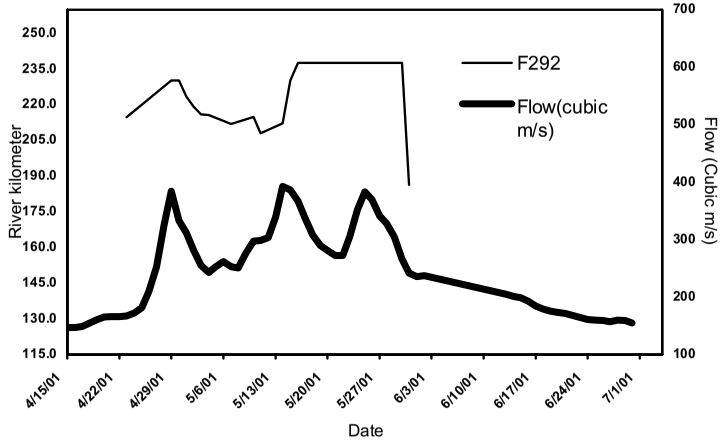


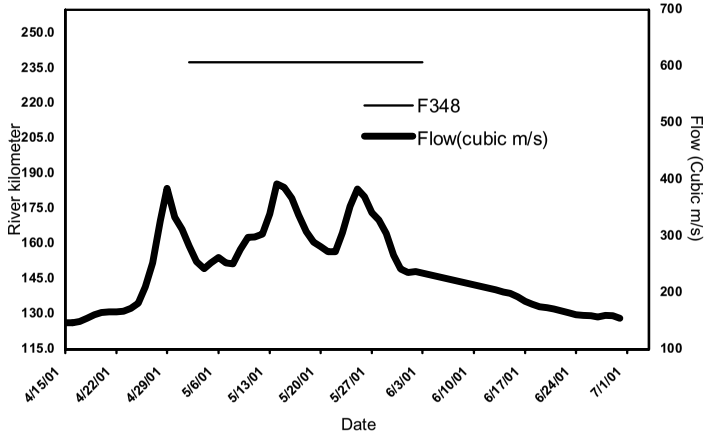


Appendix 3a Migration and flow (m^3/s) for four of ten adult female white sturgeon, five of which are believed to have spawned in the Kootenai River, Idaho 2001.

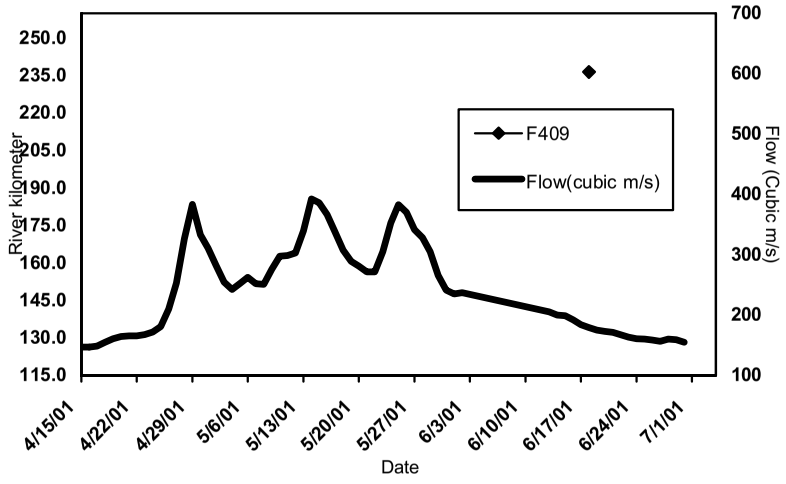


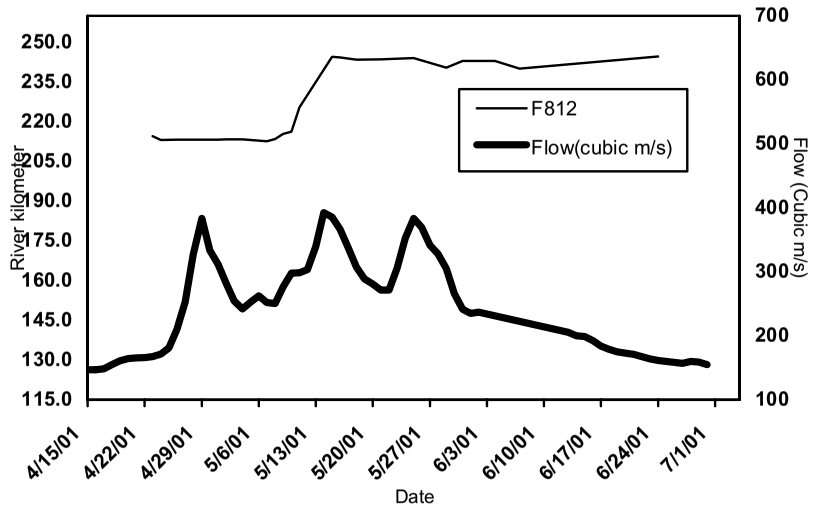


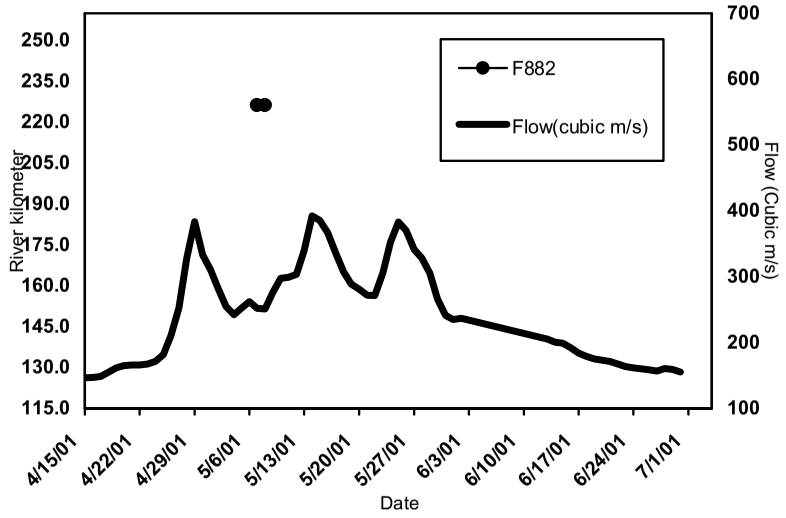


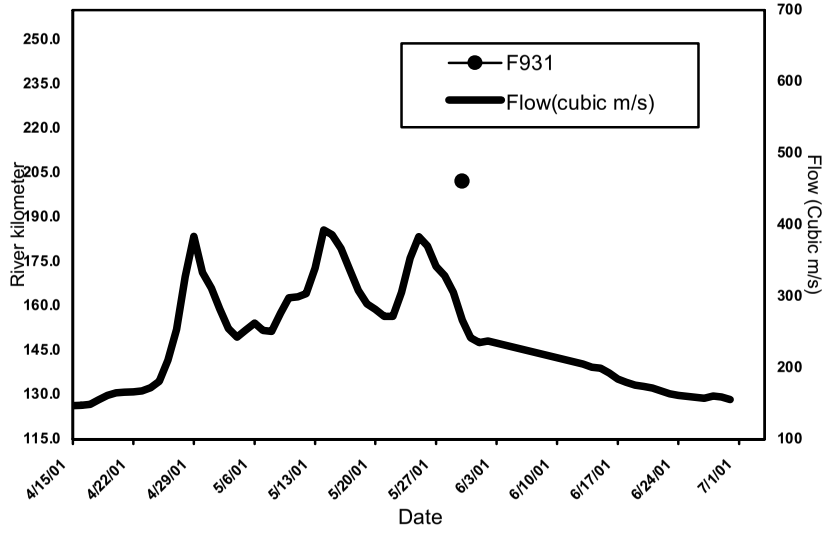


Appendix 3b. Migration and flow (m^3/s) for four of ten adult female white sturgeon, five of which are believed to have spawned in the Kootenai River, Idaho 2001.

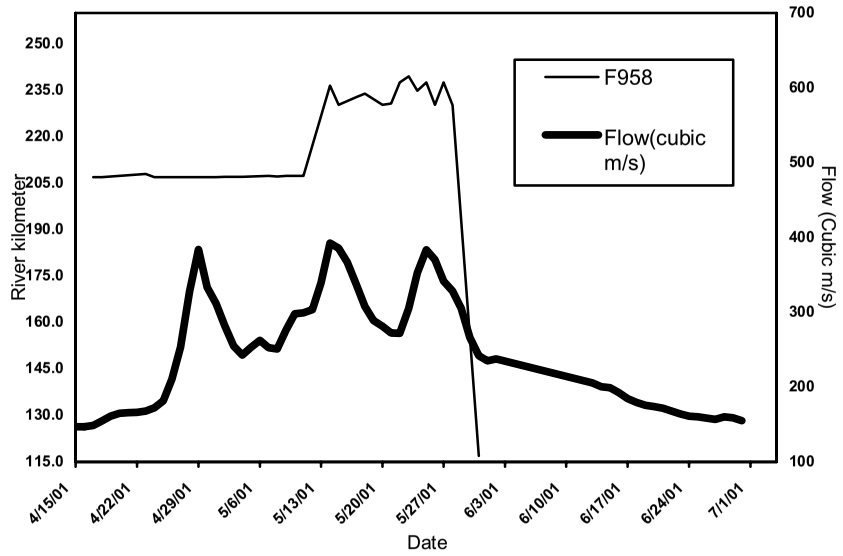


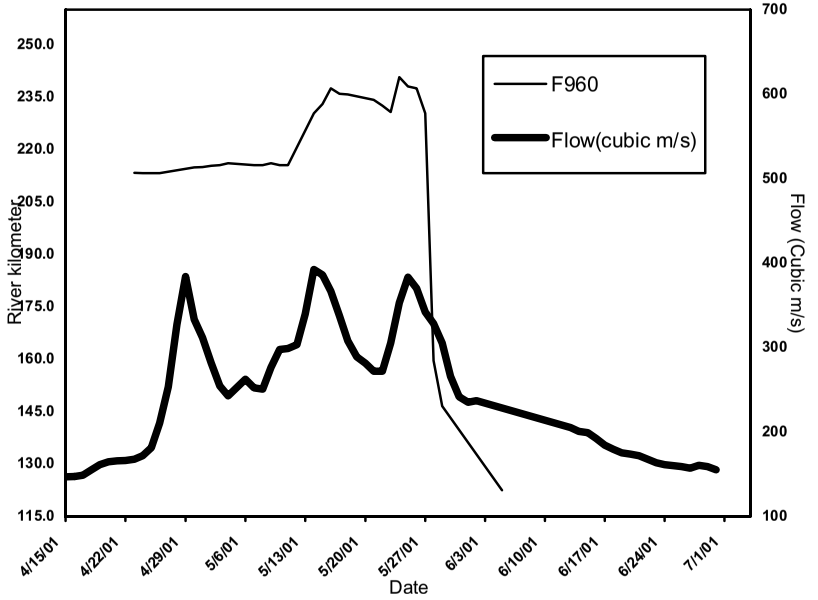




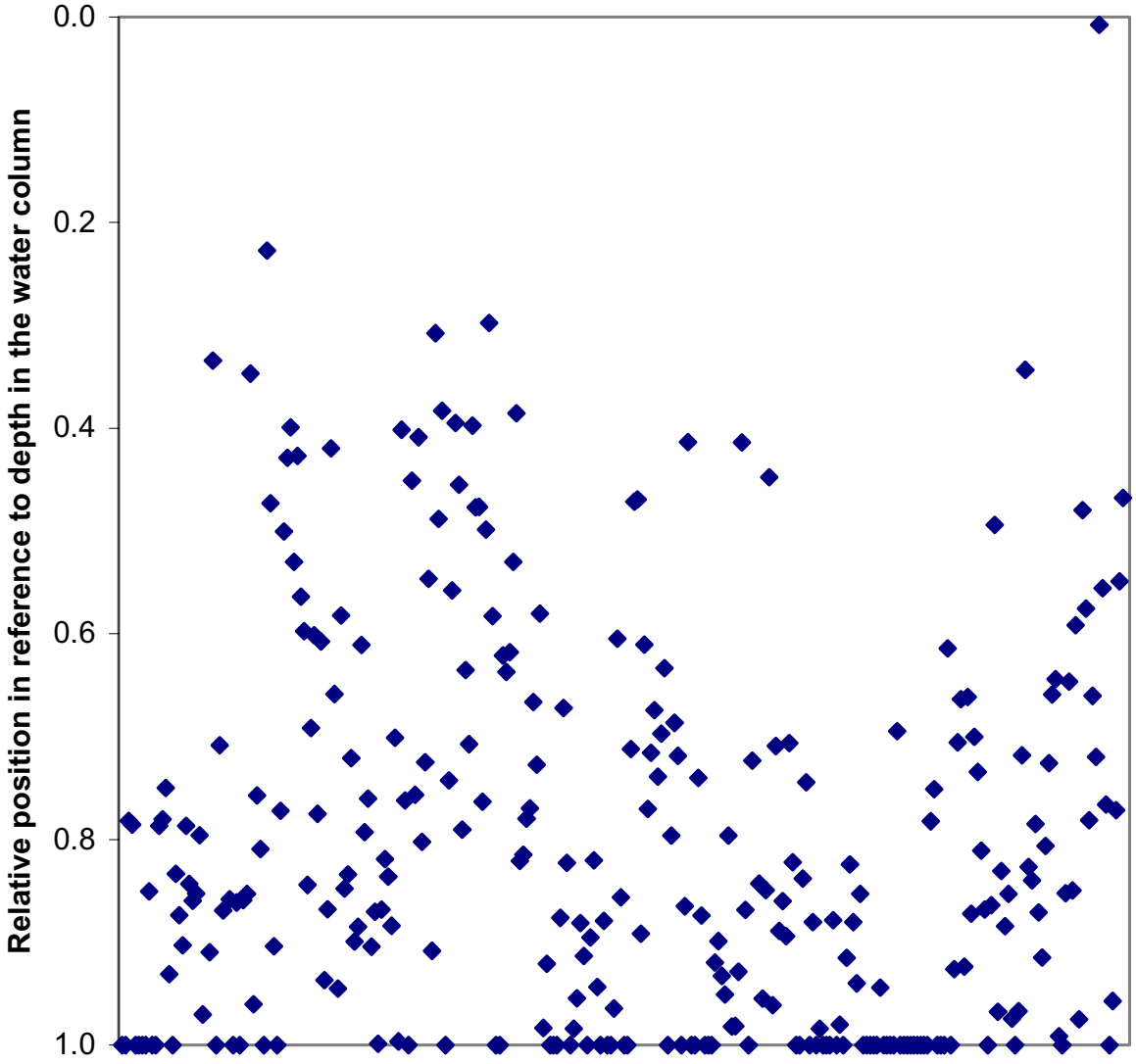


Appendix 3c. Migration and flow (m^3/s) for two of ten adult female white sturgeon, five of which are believed to have spawned in the Kootenai River, Idaho 2001.

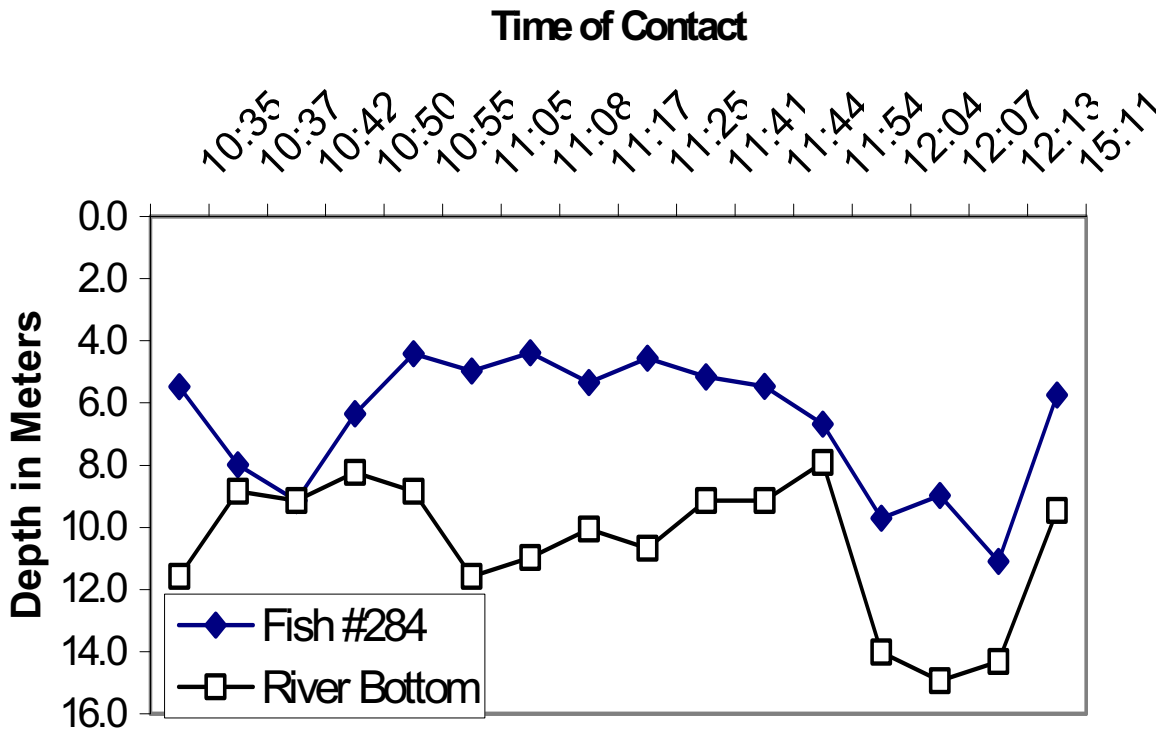




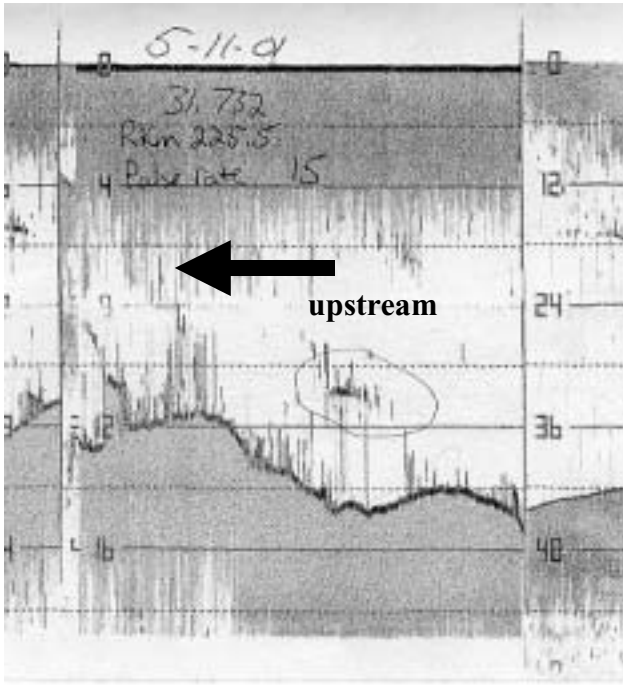
Appendix 4. A scatter plot of relative position in the water column of white sturgeon with depth sensitive tags, Kootenai River, Idaho, April 8 through July 17, 2001.

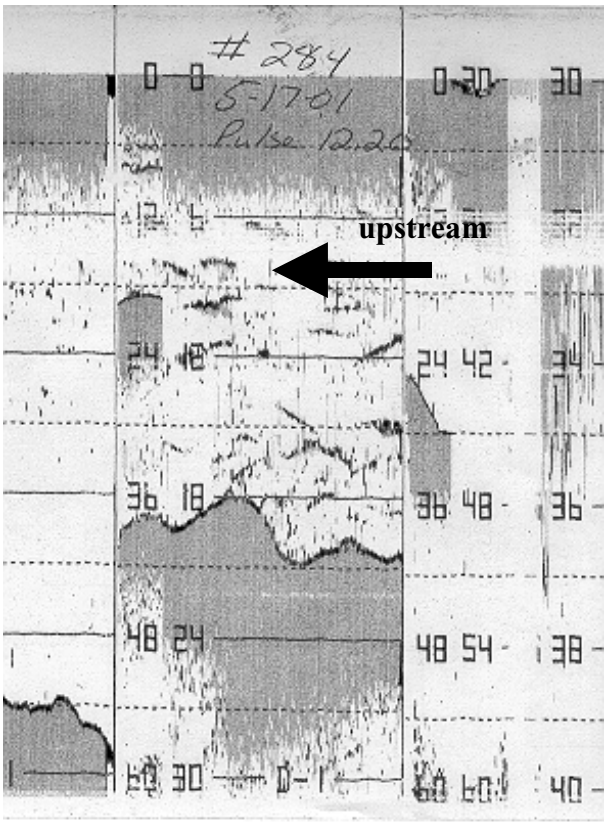


Appendix 5. Fish #284 in relation to the river bottom during a continuous telemetry observation at rkm 215.6-216.7, April 19, 2001

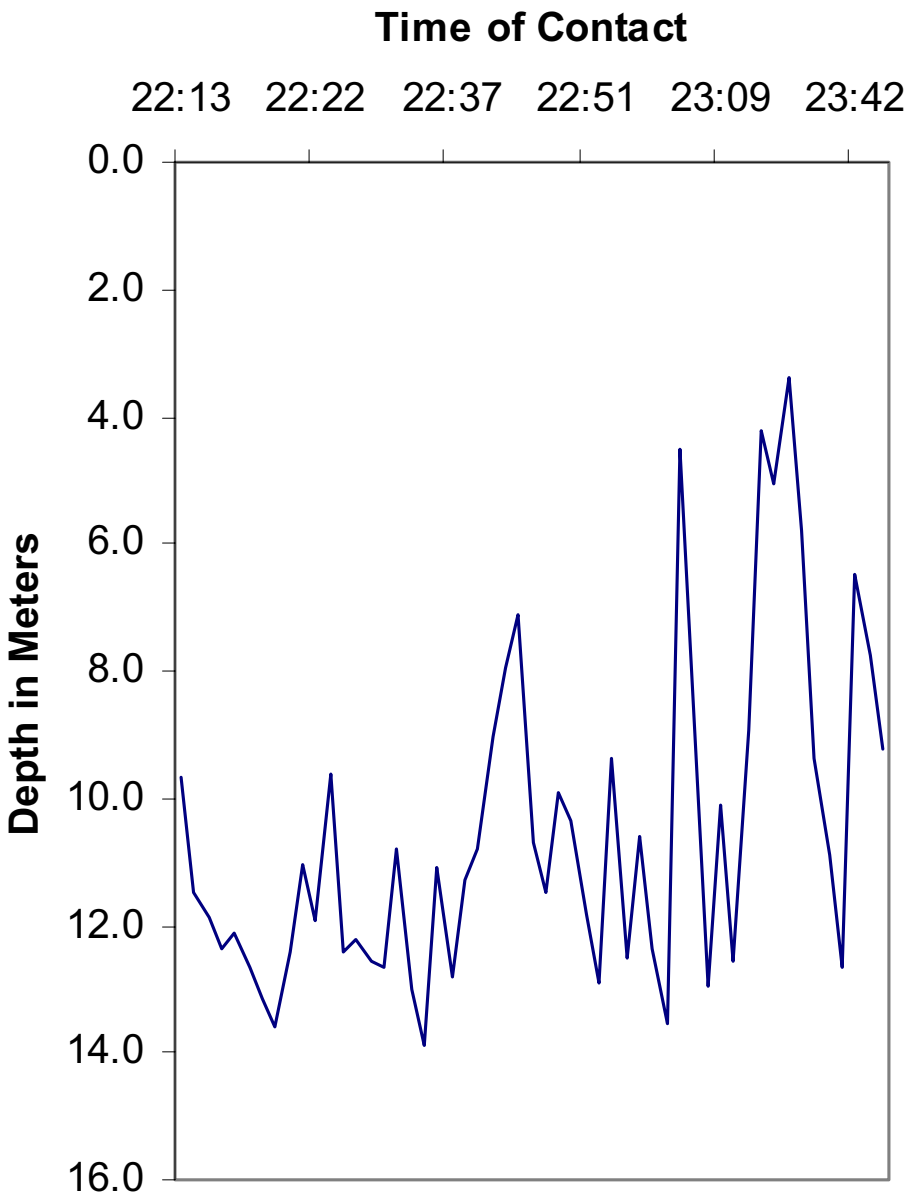


Appendix 6. Upper panel shows white sturgeon with radio 31.732 (circled) behind a sand dune at rkm 225.5. Lower panel shows sturgeon #284 with a suspected pod of adult white sturgeon.





Appendix 7. Movement of Fish #284 during a continuous telemetry observation at rkm 236.6 on May 25, 2001.



Appendix 8. River location (rkm), number of eggs, depth (m), and velocity (m/s) at sites where white sturgeon eggs were collected in the Kootenai River, Idaho 2001.

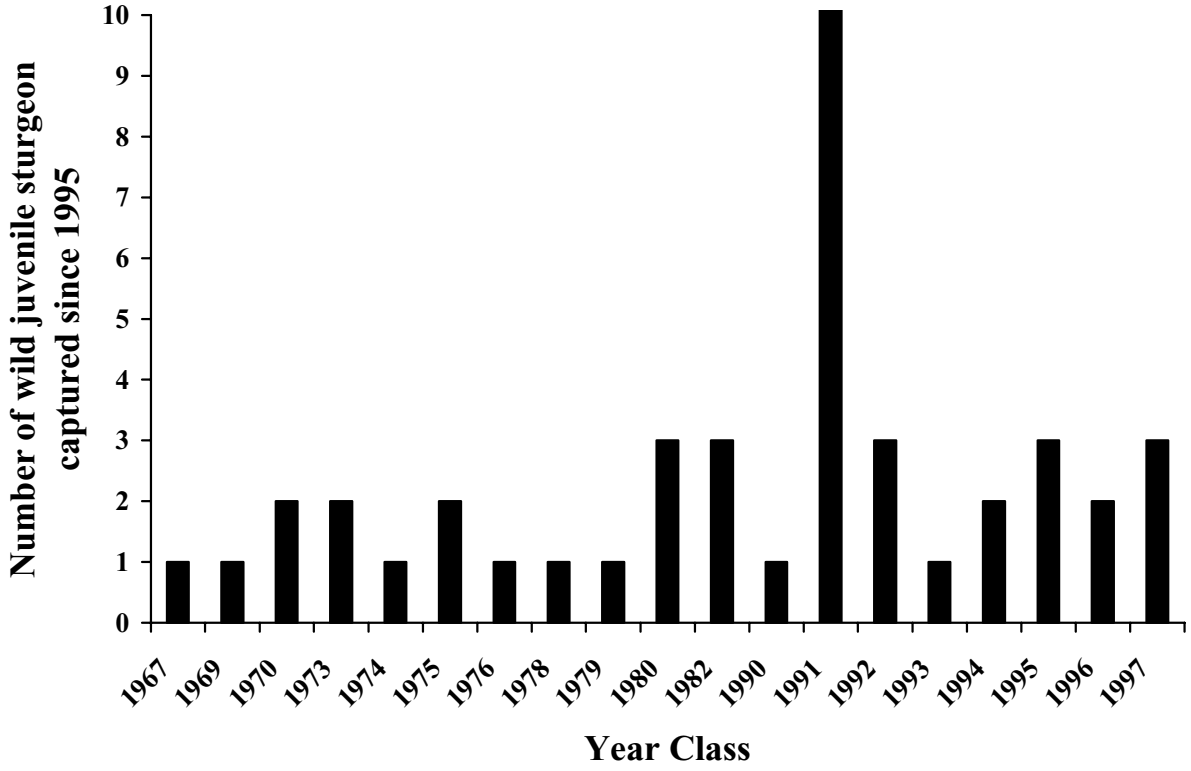
River section (rkm)	Number of eggs collected	Number of mats w/eggs	Depth range (m)	Mean depth (m)	0.2[a] Velocity (m/s)	0.8[b] Velocity (m/s)	Mean velocity (m/s)
229.6-231.5	113[c]	7	6.1-10.7	8.1	0.38	0.38	0.38
234.8-237.5	4[d]	3	6.1-11.9	10.0	0.37	0.28	0.33
244.7-246.6	22[e]	4	3.1-6.1	4.2	0.94	0.89	0.91
All locations	**139**	**14**	**3.1-11.9**	**8.1**	**0.54**	**0.5**	**0.52**

[a] 0.2 of total depth.
[b] 0.8 of total depth.
[c] Includes 53 dead/damaged eggs.
[d] Includes four dead eggs.
[e] Includes two dead eggs.

Appendix 9. White sturgeon egg collection dates, locations, habitat attributes, and staging data for eggs collected during the 2001 sampling season on the Kootenai River, Idaho.

Date	Rkm	Depth (m)	No. Eggs	Flow 0.2	Flow 0.8	Temp (C)	Stage (Number)	Spawn Date
							Dead (43)	—
							21(2)	May 27
							22(18)	May 26
							23(15)	May 26
5/29/01	230.4	7.6	86	0.47	0.33	12	24(8)	May 25
5/29/01	230.8	10.7	1	0.53	0.53	12	21(1)	May 27
5/30/01	230.4	7.9	7	0.35	0.43	10	Dead (7)	—
5/30/01	230.9	9.8	3	0.49	0.44	10	18(3)	May 29
5/30/01	236.8	11.9	2	0.32	0.31	10	Dead (2)	—
6/1/01	235.5	11.9	1	0.39	0.36	13	Dead (1)	—
6/3/01	231.0	7.6	1	0.39	0.37	12	23(1)	May 31
6/9/01	236.6	6.1	1	0.41	0.18	13	Dead (1)	—
							12(7)	June 17
6/18/01	231.0	7.0	11	0.30	0.30	11.5	14(4)	June 17
							Dead (3)	—
6/21/01	231.0	6.1	4	0.15	0.23	15	21(1)	June 20
							Dead (1)	—
							14(2)	June 21
6/21/01	245.1	3.7	4	0.54	0.65	13	16(1)	June 21
							16(2)	June 21
							17(7)	June 20
6/21/01	245.7	6.1	10	1.3	1.3	13	18(1)	June 20
							Dead (1)	—
6/23/01	245.1	3.7	2	0.54	0.32	15	20(1)	June 22
							16(1)	June 23
							18(4)	June 22
6/23/01	245.7	3.1	6	1.37	1.27	15	18+(1)	June 22

Appendix 10. Capture of wild juvenile white sturgeon by year class in the Kootenai River, Idaho, from 1995 through 2001 (year of capture is not included). An additional fish thought to be of the 1995 year class was caught in 1998, but could not be aged. Captures were made primarily by gillnets.



Appendix 11. Numbers and recapture rates of hatchery produced white sturgeon juveniles (progeny of wild broodstock) released into the Kootenai River in Idaho and Montana between 1992 and 2001 (from Kootenai Tribe of Idaho and Idaho Department of Fish and Game Annual Reports 1992-2000).

Year class	Number released	Mean total length (mm) at release (S.D.)	Mean weight (g) at release (S.D.)	Release year	Percent (#) recaptured
1990	14	455	321	Summer 1992	50.0 (7)
1991	200	255.0 (17.2)	65.9 (12.8)	Summer 1992	45.0 (90)
1992	91	482.6 (113.0)	549.3 (482.9)	Fall 1994	95.6 (87)
1995	1,076	228.5 (27.0)	47.3 (16.6)	Spring 1997	28.1 (302)
1995	891	343.7 (43.7)	147.7 (64.0)	Fall 1997	36.3 (323)
1995	99	410.4 (67.9)	287.4 (137.8)	Summer 1998	45.5 (45)
1995	25	581.5 (40.5)	863.3 (197.9)	Summer 1999	32.0 (8)
1995	—	—	—	—	(14)
1998	306	261 (42)	79.5 (44.4)	Fall 1999	6.9 (21)
1999	2,186	251.1(29.6)	70.5 (18.1)	Fall 2000	7.6 (167)
1999	—	—	—	—	(1)
1999	2,074	284.3(54.4)	107.6 (60.1)	Spring 2001	6.2 (128)
2000	3,940	244.0 (38.9)	64.2 (31.0)	Fall 2001	— (0)
?[a]	—	—	—	—	— (3)
Total	**10,902**	**—**	**—**	**NA**	**11% (1,196)**

[a] These juvenile white sturgeon had no PIT tags, and scutes were mismarked.

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